ENGINEERING EDUCATION

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THE ENGLISH DEPARTMENT.

The past month has brought to the English committee a number of very encouraging letters. Some of them have been merely expressions of appreciation of what the committee is hoping to accomplish, but many of them have brought definite evidence that everywhere there is an awakened interest in the problem of more efficient English training for the students in our engineering colleges. It is especially heartening to see that the slogan of the Urbana meeting, "Coördination and Coöperation," has inspired teachers of both technical and humanistic studies to draw nearer together in their efforts to raise standards of student English.

A letter from Professor W. R. Raymond of the Iowa State College of Agricultural and Mechanical Arts is typical. I quote in part:

"At present the various divisional faculties of the institution are discussing a plan for the establishment of a Committee on Students' English, modeled after the University of Illinois plan, which, you will remember, was explained to the English teachers last summer at Urbana. The proposal here originated with a coöperative committee within the engineering division, a committee of engineers and representatives from the departments, outside the division which teach the language arts. The plan was acted upon favorably by the Engineering Faculty somewhat over a year ago. This fall it was referred by the engineers to all divisional faculties for discussion and possible adoption as an all-college policy. Whatever the final decision on the plan may be a keen interest in student standards of English has been aroused which is sure to result in establishing standards higher than we now have on the Campus.

"Recently our Engineering group of English teachers has had helpful conferences with heads of Engineering departments and some of their associates. Discussion had to do with methods of improving English preparation of engineering students for their technical training and professional careers.

At least one valuable piece of coöperative work has resulted. There will be other such conferences."

The University of Illinois plan, to which Professor Raymond refers, does not differ fundamentally from the plan in operation at several of our colleges, but the administrative details have been worked out with such care that it seems to be producing very satisfactory results. The plan, as passed by the University Senate in March 1919, provides for a Committee on Student English consisting of five or more members appointed for the purpose of improving the quality of the English used by the students throughout the college. The Committee is not a committee of the English department but is appointed by the Council of Administration with a paid secretary who manages all the routine and supervises the special instruction which is necessary. Such a representative committee has been able to obtain the general interest and coöperation of the entire faculty in the administration of the plan. At a stated time in each semester instructors, except those in English composition, are asked to make reports, on blanks provided for the purpose, on all students whose use of English, whether oral or written, is unsatisfactory. Each report is accompanied by the evidence on which it is based. Such reports may be made at any time during the semester when the evidence is sufficient. The Committee examines the evidence of the student's deficiency, and, if the student is in need of further instruction, he is placed under the care of the secretary, who determines the kind of instruction in each case. When a student is reported by any instructor, the Secretary calls for reports from all the other instructors of that student. In this way the evidence upon each case is always made as complete as possible before action is taken. No credit is given for the additional work, but all such work is a requirement for graduation.

The report of the Committee at the end of its first year indicates that the experiment was very successful. The attitude of the students was such that the work of the Committee was accomplished without friction, and a surprising

amount of coöperation was given by the faculty. The knowledge of the existence of the Committee had an immediate tonic effect on the quality of student English throughout the University. It is planned to expand the work to include advisory service to students who voluntarily seek advice in the preparation of theses and long papers.

At the University of Illinois the Committee on Student English is, of course, a university committee, but there seems to be no reason why the experiment could not be tried on a more limited scale in an engineering college where the entire university is not yet ready to unite on the plan. It may be presumptuous for the chairman of the English Committee, but he is quite sure that if any school should be interested in getting more detailed information, the Secretary of the Committee at Illinois would be glad to supply such information. Address, Secretary of the Committee on Student English, 324 University Hall, Urbana, Illinois.

ANNUAL MEETING.

The program for the annual meeting is well under way. The following features have already been arranged by the Local Committee:

Wednesday noon, luncheon for the Council.
Wednesday evening, President Livingston Farrand's Welcoming Address and Reception.
Thursday afternoon, Open House and Inspection Tours.
Thursday evening, Annual Dinner and Presidential Address.
Friday evening, Round Table–Smoker.
Saturday afternoon and Sunday, Excursions and visiting.

Special entertainment is being provided for the ladies and will be announced later.

Requests have come in for camping privileges for tourists. These are being arranged.

CORNELL UNIVERSITY.

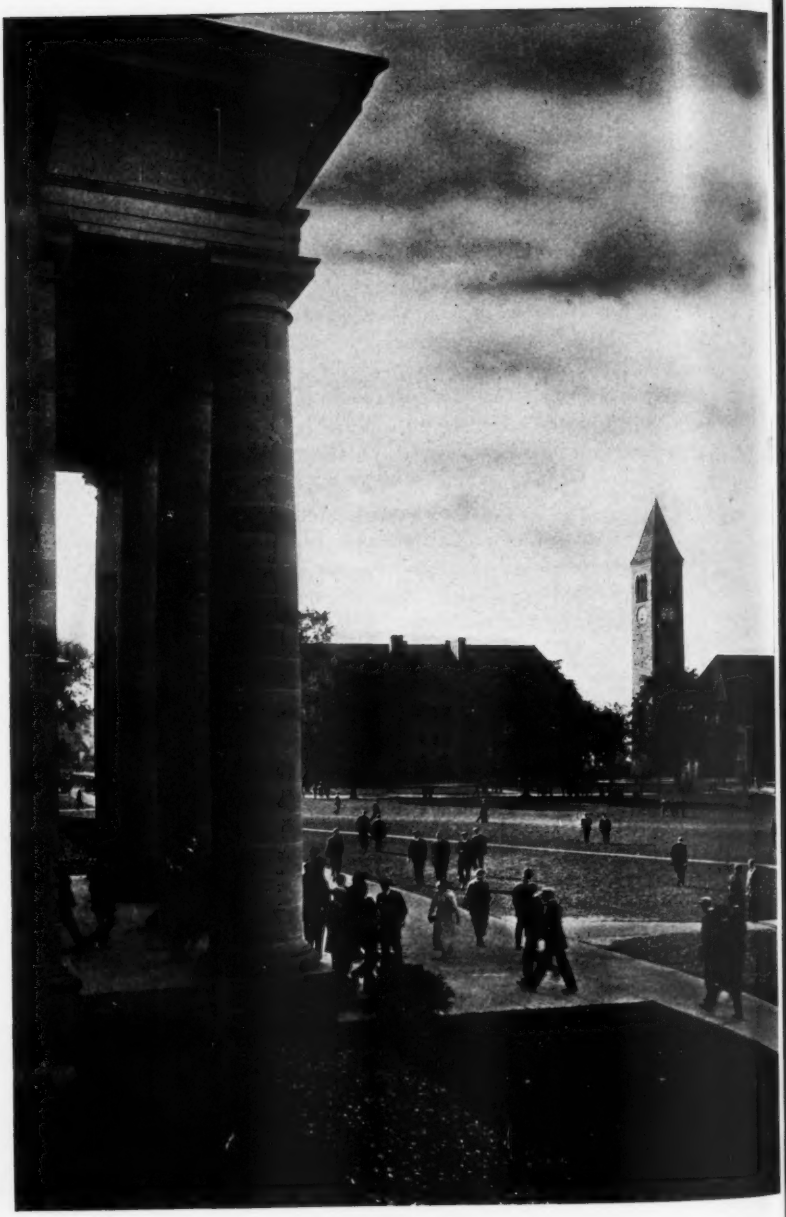
Cornell University, one of the larger institutions of higher education in this country, in common with many of the State universities of America, had its origin in the Federal Government's grant, for the endowment of education, of a large portion of the public lands, under the authority of the Morrill Act, an Act of Congress approved by President Lincoln on July 2, 1862. Although it owes its foundation primarily to this grant, the University is indebted in a far greater degree to Ezra Cornell and Andrew Dickson White, to the one for its material wealth and to the other for its educational dimension.

The purpose of the Morrill Act was to endow in each State at least one college whose leading object should be, "without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the legislatures of the States may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life."

Cornell University was granted its charter by the State of New York in 1865, and was named in honor of Ezra Cornell. In 1864 Andrew Dickson White suggested to Ezra Cornell, his fellow member of the State Senate of New York, that they found a new type of university—an institution that should be broad, liberal, non-sectarian, to meet the ever-increasing need for practical training and to give instruction in the sciences as well as in the humanities. Mr. Cornell then offered the State $500,000, (with 200 acres of land), as an endowment, if the State would add to the fund the proceeds realized from the sale of public lands granted by the Morrill Act. The State accepted Mr. Cornell's offer and the Charter copied the words quoted above from the Morrill Act and

amended them by adding that "such other branches of science and knowledge may be embraced in the plan of instruction and investigation as the trustees may deem useful and proper." In words that have become famous Ezra Cornell stated his ideal: "I would found an institution where any person can find instruction in any study."

Mr. Cornell's service as trustee of the University's lands is little known or understood. The educational land grant of 1862 was apportioned among the States according to their representation in Congress, and the Federal Government issued to them scrip, in each instance for a certain number of acres yet to be located in the public lands. But no State could locate or take title to land within the domain of any other State and because the public lands were mostly in the West, the Eastern States as a rule offered them for sale at once. The market was glutted and the price fell to fifty cents an acre or less. For that reason many States realized only insignificant sums from their shares of the grant. New York's share was 990,000 acres. The State was disposing of the scrip at prices which Mr. Cornell saw would provide but a meager endowment for the University. Seeing that the lands must be located and held for a much better price unless the University was to be beggared at the start, he made an agreement with the State, binding himself to purchase its remaining scrip, about 914,000 acres, to locate the lands within four years, and to sell all the lands within twenty years, and to pay all the proceeds to Cornell University. That was in 1866. During the next eight years, until his death in 1874, Mr. Cornell bent all his great energies to the task of locating good farming and timber lands in Kansas, Wisconsin, and Minnesota, and of conserving that potential wealth. After his death, his successor as chairman of the board of trustee, the late Henry W. Sage, continued Mr. Cornell's policy with regard to the lands. From the sale of this property the University eventually realized more than five million dollars. This endowment is far greater than that any other State obtained from its share of the land grant. It is more than



QUADRANGLE.

one-third of the whole sum realized by all the States from the grant, although New York's share of the acreage was only about one tenth. In no other State did there appear a benefactor like Ezra Cornell, who bought and located lands for the sole benefit of the State.

The Charter directed that the University be located in the town of Ithaca. This had been Mr. Cornell's wish, and it was he who determined the site, with the approval of the Trustees, by giving the University more than two hundred acres of upland overlooking Cayuga Lake. On this spot, amid bold and beautiful scenery, Cornell University was built.

Although there was bitter opposition from the press and the denominational schools of the State, the University was incorporated and on September 5, 1865, the trustees met for the first time.

Andrew Dickson White was elected the first president of the University, and he was allowed absolute freedom in putting his educational scheme into effect. Among the things that he desired to accomplish were the following: He desired to have closer unity between the advanced and the general educational systems of the State to give liberal instruction to the industrial classes, to stress technical instruction, to have unsectarian control, to have taught " a course in history and political and social science adapted to practical needs of men worthily ambitious in public affairs," to go more thoroughly into the study of modern languages, with especial emphasis on English, to make a "steady effort to abolish monastic and pedantic instruction," to institute an elective system of studies; and to have non-resident lecturers.

Cornell University opened on October 7, 1868, and 412 men applied for admission, many of them desiring to work their way. During the next fifteen years Ezra Cornell had to lend his help to the institution which was in financial difficulties. He paid salaries, supplied necessary equipment, and finally in 1866 bought the State's scrip for the land grant. During this trying period, however, the University had many famous men to lecture in its hall, among the non-resident lecturers

LINCOLN HALL. CIVIL ENGINEERING.

being James Russell Lowell, Louis Agassiz, G. W. Curtis, Bayard Taylor, Theodore D. Dwight and Goldwin Smith (resident professor from 1866–69).

The University was put on a financially sound footing through Mr. Cornell's efforts, and its student body increased rapidly. In 1884–85 the student body was 585, while in 1897–98 it had grown to 2,120. The University has had four presidents, Andrew Dickson White (1867–1885), Charles Kendall Adams (1885–1892), Jacob Gould Schurman (1892–1920), and its present head, Livingston Farrand.

The University is situated in a picturesque region—the lake country of the State of New York. Its domain of fourteen hundred acres occupies the brow and crest of a hill overlooking the town of Ithaca, twenty miles of Cayuga Lake, and the surrounding country. The campus is eight hundred feet above the level of the lake. The country about Ithaca is a plateau, moulded by glacial deposit and by erosion into rolling landscapes. Its unusual picturesqueness is due to the presence of a few extraordinary valleys, long and narrow, and deeply cut in the rock of the plateau, forming lake basins. Two gorges, those of Fall Creek and Cascadilla Creek, are on the borders of the Campus.

In the gorge of Fall Creek are many cascades and two great cataracts, the Triphammer Falls and the Ithaca Fall. Just above the Triphammer is a dam, built by the University, impounding a reservoir of about twenty acres which is called Beebe Lake, and diverting a part of the stream to the hydraulic laboratory of the college of engineering.

Cornell University comprehends the Graduate School; the College of Arts and Sciences; the College of Law; the Medical College (including the Medical College in New York City and the Ithaca Division of the Medical College); the New York State Veterinary College; the New York State College of Agriculture; the College of Architecture; the College of Engineering (comprising the School of Civil Engineering, the Sibley School of Mechanical Engineering, and the School of Electrical Engineering).

The University Library, originally the gift of Henry Williams Sage (1891), is situated in the west central part of the campus. It is of light grey Ohio sandstone, and contains the general library, the seminary and departmental libraries, and the forestry library.

The library forms a quadrangle with the following buildings: Morse Hall, Franklin Hall, Sibley College, Lincoln Hall (houses the College of Civil Engineering), Goldwin Smith Hall (for language and history), Stimson Hall (given by Dean Sage to the Medical College), Boardman Hall (housing the College of Law), Morrill Hall (contains the administration offices), McGraw Hall and White Hall.

Sage Chapel, which has beautiful interior decorations; Barnes Hall (home of Cornell University Christian Association); Sage College (a dormitory for women); the Armory and the Gymnasium, form the southern part of the qaudrangle.

The east of the quadrangle is made up of the Rockefeller Hall of Physics and the New York State College of Agriculture. To the Southeast of the quadrangle is the New York State Veterinary College.

Many fraternity houses have been built on lands adjacent to or near the University grounds, and some on the Campus itself. North from the Campus, across the bridged gorge of Fall Creek many members of the Faculty and a few fraternities have built houses. The University itself has acquired some large tracts of land in that northern section and the Campus is absorbing them. Prudence Risley Hall, a residential hall for women, the gift of Mrs. Russell Sage, is situated there.

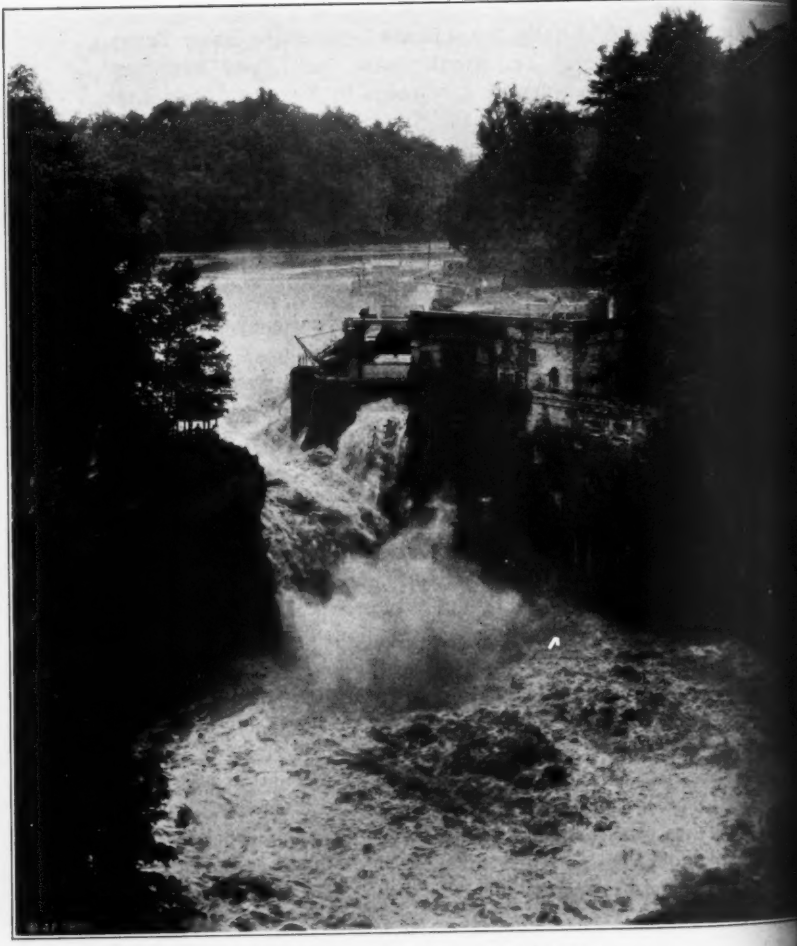
Since most of the men students have had to find lodgings outside the Campus, fraternity houses have been used to a great extent for living quarters. Most of the well established college fraternities are now represented at Cornell. The chapter houses provide for twelve hundred to fifteen hundred members and board for an even larger number. To the interest of the late George Charles Boldt the University will

owe a beautiful group of residential and dining halls which is taking form below West Avenue. Construction was begun in 1914 and four halls, Baker Court (comprising Baker Tower, North Baker Hall and South Baker Hall), and Founders' Hall, have been completed. George F. Baker, of New York City, gave $350,000 for the first three buildings, and the Trustees voted $100,000 from the Alumni Fund to construct the fourth.

The University is well equipped with laboratories. Especially noteworthy are the psychological laboratory, the laboratories of Sibley College, and the hydraulic laboratory of the College of Civil Engineering.

Students have the use of about sixty acres of the Campus for athletic sports. The Trustees in 1903 set apart fifty-seven acres of the University's farm for a playground and athletic field. This land lies south of the College of Agriculture and east of Garden Avenue. The athletic field, known as the Alumni Field, is for the most part not enclosed and is open to the use of students generally, under the regulation of the department of physical training. The southern part of Alumni Field is devoted to the uses of the Cornell University Athletic Association. Schoellkopf Field and Stadium is used chiefly for football games and that group of sports known as track athletics Around the football field is a quarter-mile oval cinder path. The stadium is of reinforced concrete, under-drained, and has seats for nine thousand spectators. Schoellkopf Memorial Hall, bounding the north end of Schoellkopf Field, was given to the University by the late Willard Straight of the class of 1901, in memory of Henry Schoellkopf of the class of 1902. In the basement of this building are dressing rooms and baths for the use of the Cornell athletic teams and visiting teams. On the main floor are the offices of the Athletic Association. The attic floor is occupied by a gymnasium.

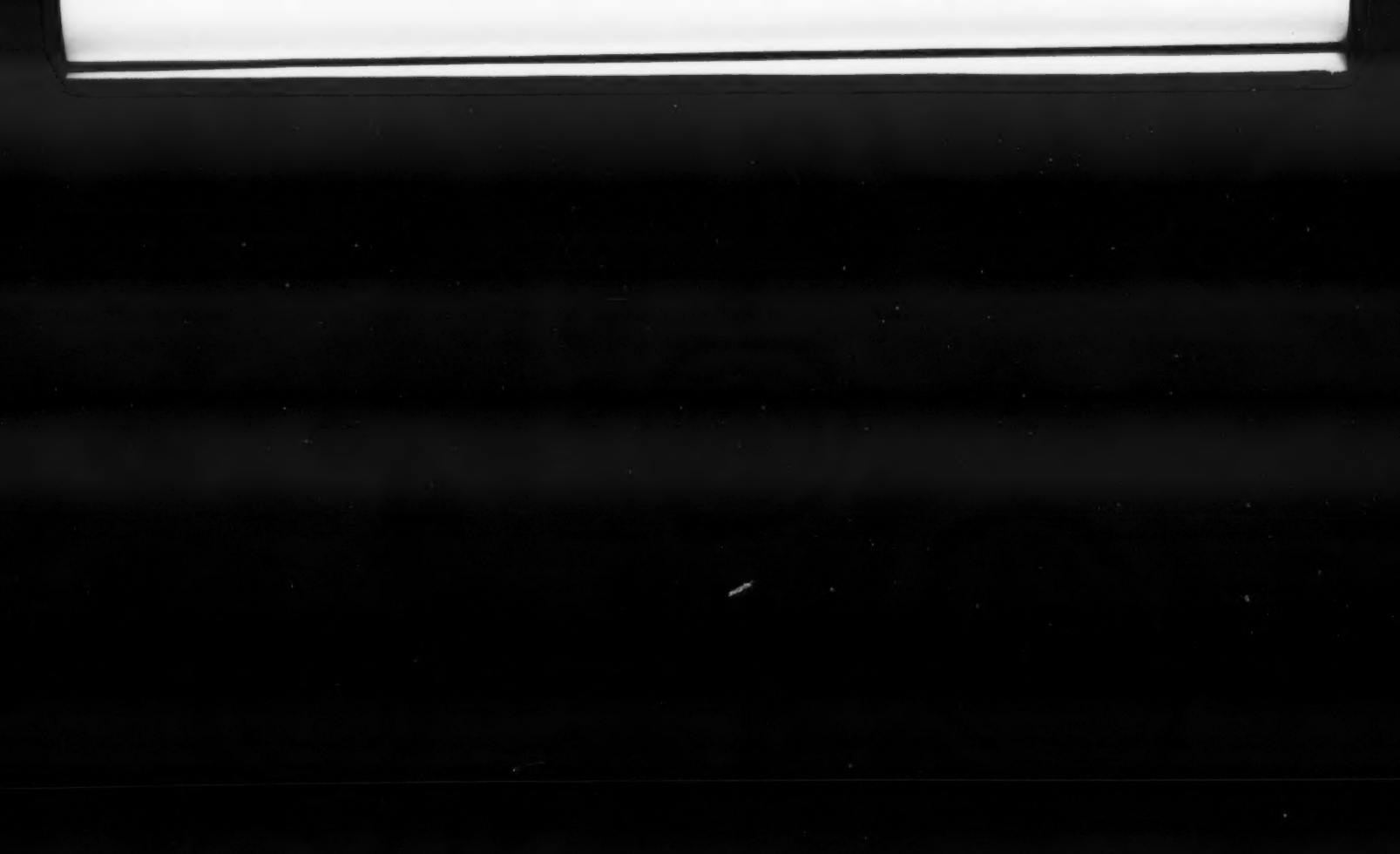
The University Boat-House is situated on the east bank of the Cayuga Inlet. The present structure was built in 1890 by the graduating class of that year. Cayuga Lake gives



THE HYDRAULICS LABORATORY.
FALL CREEK AT FLOOD.

GENERAL VIEW OF CO

F CORNELL CAMPUS.



opportunity for water-sports and the Cornell rowing crews have long been famous.

The Women's Playground occupies about two acres of level ground at the bottom of the Cascadilla ravine, south of Alumni Field.

Those male students who are candidates for a baccalaurate degree and who are officially relieved of military training are required to take a stated amount of physical training, as are the women undergraduates.

The University has achieved a high reputation in philosophy. The "Susan Linn Sage School of Philosophy" issues *The Philosophical Review* and *Cornell Studies in Philosophy*, which has contained the well-known psychological laboratory investigations under Professor Edward Bradford Tichener. The College of Agriculture is equally well-known, as are the "Cornell School" of Latin grammarians, the department of entomology, and the department of physics.

The University publishes: *Cornell Studies in Classical Philology; The Journal of Physical Chemistry; The Philosophical Review;* memoirs of the Agricultural Experiment Station; *Cornell University Medical Bulletin;* catalogues of special University library collections; publications of the Medical College; the official publication; *Cornell Studies in English; Islandica,* an annual relating to Iceland and to the Fiske Icelandic Collection in the Cornell University Library. The Sibley Journal of Mechanical Engineering and the Cornell Civil Engineer.

The University charges $250 tuition fees for the regular year in Ithaca, and $300 in the Medical College in New York City. No tuition is charged in the veterinary and agricultural colleges to residents of New York State. The Commissioner of Education is empowered every year to award one scholarship for each Assembly District in the State.

The charter provides that the University shall always be non-sectarian.

The government of Cornell is vested in a President elected by the Board of Trustees, and a Board of Trustees, consisting

of the President of the University and forty-two other members, of whom seven are *ex-officio*, viz.: the Governor of the State of New York, the Lieutentant-Governor, the Speaker of the Assembly, the Commissioner of Education, the Commissioner of Agriculture, the President of the State Agriculture Society, and the Librarian of the Cornell Library. The eldest lineal male descendent of Ezra Cornell is a trustee. The internal government is in the hands of the faculty, made up of the President, the Professors and Assistant Professors, the Librarian and Assistant Librarians, the Registrar, the Secretary of the University, and the Dean of Women. The special faculties have jurisdiction over distinctly college affairs.

The land and buildings and the equipments of the University have an estimated value of $9,068,661.73. The productive and other funds of the University amount to $19,565,624. The current income of the University for the year 1920–21 was $5,543,275. The expenses of the University for the corresponding period were $4,771,689.59. The State of New York appropriated for the College of Agriculture and the Veterinary College $1,533,115.75, in the same period which is not included in the income given in the foregoing.

Cornell University has had about the same number of regular students as it has now for the last eight or ten years, except during the two war years, 1917–19. The University's policy is to hold the number at not more than about five thousand for the present, in order to maintain the quality of the teaching and to prevent over-crowding. The entrance requirements are kept high and are rigorously enforced.

The number of regular students enrolled in October 1922 was 5,188, distributed as follows: Graduate school, 447; arts and sciences, 1,701; medicine, 223; law, 80; agriculture, 1,095; engineering 1,547; architecture, 177; veterinary medicine 89. There were 2,146 students in the summer session of 1922.

The faculty numbered 788, of whom 261 were professors, 164

were assistant professors, and 353 were instructors (not including assistants).

The number of volumes in the library was 670,000.

Instruction in engineering was instituted at Cornell University at its founding, and the College of Mathematics and Engineering and the College of Mechanic Arts were opened when instruction began, in 1868. The former of these consisted of two schools, namely, the School of Mathematics and the School of Engineering. In 1871 Mathematics was separated from Civil Engineering, and Architecture was added to it, thus forming the College of Civil Engineering and Architecture. In 1873 Architecture was separated from Civil Engineering, and the latter existed as a department until 1890 when the College of Civil Engineering was established.

Courses in Electrical Engineering were first established at Cornell in 1883, under the guidance of the Department of Physics. In 1889 the direction of the professional courses in Electrical Engineering was transferred to Sibley College and the present course in Electrical Engineering has been developed within that college.

In 1919 the Board of Trustees, recognizing that the fundamentals of all engineering are common, voted to consolidate all engineering instruction at Cornell in one institution to be called The College of Engineering, and this action of the Board has now been carried into effect. The combined college consists of three schools, namely, the School of Civil Engineerin, the Sibley School of Mechanical Engineering, and the School of Electrical Engineering. The last-named school has been developed from the Department of Electrical Engineering, formerly a part of Sibley College. There are obvious gains in administration through the consolidation, and it is believed that the new college will serve the nation more efficiently than ever and that, through this combination, engineering education at Cornell University has been greatly advanced and brought into harmony with the progress of industry.

TEACHING ENGINEERING SUBJECTS TO FRESHMEN IN COLLEGE, WITH SPECIAL REFERENCE TO MECHANICAL DRAWING AND DESCRIPTIVE GEOMETRY.

BY MORRIS WENK,

Assistant Professor of Mechanical Engineering, Oregon Agricultural College.

In the great development of manufacturing in the United States in the last seventy five years, which has used and inspired the ingenuity and talent of the engineer to a marvelous degree, there has been a close interrelation between the inventive genius who furnished the ideas of machines or what not, the engineer who developed them to commercial production and the financial man or manager who handles the getting together of the raw materials and the distribution of the finished goods. In the beginning these three functions were in most cases performed by one person. The inventor furnished the idea or invention, made the machinery with his own hands, and attended to the factory details of getting the raw materials, manufacturing and selling the finished article.

In modern production the one-man shop can hardly be said to exist. In numbers it is so few and in output it is so small that it will not be considered in this discussion, the principles developed will apply just the same.

It is a commonplace to say that invention is the foundation of modern industry, particularly American industry and various people, orators on the Fourth of July and at other times, are wont to discourse at length on this "glory of America." These gentlemen conveniently forget or never knew that laboratory work or the filing of a patent specification were only the embryonic stage of industry. They don't know that the successful modern industry is the result of

great sums of money and time spent in working out an idea into a commercial product. As one instance of hundreds, Thomas A. Edison worked and experimented ten or twelve years on his storage battery before it was put on the market, and Sir Charles Parsons, the inventor of the Parsons steam turbine, remarked "Every successful engineer has a big scrap pile behind him." *The engineer must develop the idea.*

The province of engineering has been stated to be "The economical progressive use and coördination of the materials and forces of nature and human labor for the benefit and advancement of mankind." With such a high mission engineering needs high thinking and high thinking postulates adequate preparation. Backing up the conception of high thinking is what 6,773 practicing engineers reported in their answers to a joint committee of the National Engineering Societies on what they considered most valuable in young men coming to them, wherein seventy five per cent. rated moral qualities highest (character 94.5 per cent.) and technical training the more desirable by twenty-five per cent., which is a modern restatement of the words, "It is written 'Thou shalt not live by bread alone.'" Not that we can live without bread at all, but that even to an engineer, iron and steel and mathematics are not the whole of the matter.

The development of the invention to the stage of commercial utility, the use of the forces and materials of nature for the benefit of mankind, the organization of human labor and out of it all getting the highest efficiency, the greatest output for the least input, all this as the work of the engineer can only be done by trained men. Some of this training is only obtained by experience but the foundation is got in the Engineering School.

As indicated above, the men in practice value moral qualities more highly than technical subjects in young graduates coming to them but they do not at all say that technical subjects may be ignored. Technical training must be there. Moral training is not ordinarily stated as a part of the cur-

riculum of engineering schools but the character of the general subjects of the courses gives the finest kind of a foundation for it. Engineers deal with the forces and materials of nature and nature never lies, never fails. Seeming failures are failures on man's part. Dealing thus with unimpeachable integrity, if the teachers of engineering are of good character and are intellectually honest they can do a great deal toward moral training.

In this technical training the courses of the various engineering schools over the United States are very much alike. In general the first two years are uniform for all courses and in the third and fourth years the student takes subjects relating to the particular field he desires to go into. Many schools use a fifth year intensively on the major subject.

The detailed content of the courses has been the subject of a great deal of discussion which is by no means ended at the present. It has varied from time to time and Charles R. Mann in "A Study of Engineering Education" (Carnegie Foundation for the Advancement of Teaching, 1918) gives quite an elaborate history of the changes. This study was made at the instance of the Joint Committee on Education of the National Engineering Societies, which shows that the practicing engineer is deeply interested in the work of the engineering school. For some years before undertaking this study engineers had felt that improvements in engineering schools were possible, in fact were imperative as the product was not up to the mark. In addition the large manufacturers were exerting their pressure particularly in the electrical field.

The engineering educators are awake to the situation and for thirty years the Society for the Promotion of Engineering Education has been at work improving the courses and interesting the educator to become a better teacher. Probably this is the only society which definitely tries to improve college teaching. The annual meeting of the American Society of Mechanical Engineers held at New York in December, 1921, gave one session to a joint discussion with the En-

gineering Education Society on improving engineering education and the annual convention of the American Institute of Electrical Engineers at Niagara Falls, Ont., in June, 1922, gave one session to engineering education. The recent annual convention of the Engineering Education Society held at the University of Illinois in June last devoted the major part of the time to considering how to improve teaching.

The content of the courses as has been stated is much the same in the better engineering schools all over the United States, the less good following somewhat in the rear but substantially along the same road. The courses comprise work in mathematics, physics, chemistry, drawing, English, mechanics and special subjects related to the special or particular branches of engineering. Since the war there has been more and more insistence on training in the wider commercial aspects of engineering and the requirement of studies in economics, money and banking, costs, salesmanship and handling of men.

At the Niagara meeting of the American Institute of Electrical Engineers referred to above insistent emphasis was put on training in the fundamentals—the specific applications can be made, can be taken care of when the student gets into the practical work. What the fundamentals are has not been precisely defined, but nearly every outline which mentions any by name includes mathematics, physics, chemistry, drawing and English. Some omit drawing.

This applies to all engineering courses. In what has been written above reference has been more especially to manufacturing—to the machinery end of engineering—which would seem to overlook the civil engineering division, but the general principles applying to other than civil apply with equal force to it. Civil engineering came over from military engineering, which had to do with roads, forts, harbor works and the like for military purposes and now has to do with the civil or non-military work of ordinary roads, railroads, bridges, irrigation and reclamation works, etc. For a long time military engineering was the only kind taught and later

the only non-military engineering thought to need training was civil engineering. Training for these branches was acknowledged to be necessary.

One distinguished engineer (S. E. Doane, chief engineer of the National Lamp Works) in a paper read at the Niagara meeting referred to above, stated that "The college should perform six functions. It should offer directly:

"1. Instruction in engineering knowledge. This might be subdivided into the teaching of
  "(*a*) Fundamentals,
  "(*b*) Specific applications.
"2. Instruction in non-engineering subjects such as English, Economics, Law, etc.
"3. Instruction and training in hygiene.

It should also make adequate provision for

"4. Inculcation of habits of clear thinking, concentration, persistence, observation, decision, imagination, etc.
"5. Infusion of principles of fairness, unselfishness, tolerance, refinement, courtesy, etc.
"6. Formation of friendships.

"Obviously no special courses to teach clear thinking, concentration, persistence, observation, decision, etc., can or need be given. It nevertheless appears to me that these qualities should be taught. Every instructor in teaching a subject knows that he is teaching more than just that one subject. He knows that he is also conveying lessons in perception, efficiency, decision, and so on as a part of the more specific study. For example in teaching drawing, he emphasizes accuracy, neatness, observation, etc. If the instructor will always bear in mind that he is teaching more than the facts or principles involved in a particular subject he will do much to mould his students into efficient and productive contributors to the common good."

A student at one end of a log and a Mark Hopkins at the other—a martyred president said that was a college.

Ah yes!

But—

What subtle thing was present there which made it a college? What bond or path between two human beings, the student and a Mark Hopkins? Not the log, there are logs aplenty, not any two people, but pupil and teacher. Teaching, that is the bond, teaching wherein is knowledge as the firmer structure and character, personality, enthusiasm, patience as the subtle essence. The student shall learn, a subtle process; the teacher shall teach, he shall share his life with the student.

Present day industrial development is the work of the engineer. It may with truth be claimed that in all material ways wherein the world is more comfortable and safer now as compared with the time of Luther, the work of the engineer is preëminent. He has used the materials and forces of nature and coördinated the labor of man to advance civilization. And it may be the engineer will be the one who will preserve present-day civilization; soldiers, lawyers, priests, poets, have failed to save other civilizations, maybe they will fail this one too.

The engineer must be taught, must be trained.

Engineering is the commercial use of physics and physics uses mathematics as its natural language. Engineering uses it as a tool. The engineer must be able to use the English language and be facile in its use, be able to express himself. In addition to the above, engineering has a language of its own, a graphical universal language—mechanical drawing.

The language of mechanical drawing has many of the characteristics of other spoken or written languages. It has a vocabulary of lines, a grammar, conventions, idioms, diction and an elegance of style. It is universal, as one who is versed in it may express his ideas in one part of the world and have them understood and executed thousands of miles away. The engineer expresses his designs in it, tells in it how he wants a road, or a bridge, or a steamship, or a piece of machinery to be built, tells the materials, the sizes and

shapes of all the parts. This engineering epistle is sent to the shop or to the place where the work is to be done and the workmen build what is asked for. The language is purely graphical and in a way is an engineering shorthand.

The designing engineer cannot take the time to write out or dictate a long-hand description of an intricate piece of machinery, he cannot go down to the shop and personally stand over a workman and tell how to make all the pieces of the machine nor can he do the work with his own hands, but he can use the language of drawing and clearly indicate things which are very difficult to describe in ordinary language. Even in specifications relating to the work he does not attempt description, he writes, "To be built as shown in the drawings." When neatly done by a skillful man, mechanical drawing has an elegance and style comparable to other fine literature.

Engineering schools have recognized the importance of drawing from the beginning and Charles R. Mann in his survey shows that three leading engineering schools had drawing in their courses in 1849, 1865, and 1867. Descriptive geometry is scientific mechanical drawing and mechanical drawing unconsciously uses much descriptive geometry, not knowing its source.

How to teach? How to teach mechanical drawing and descriptive geometry? How to teach them to freshmen? How to teach better than he has in the past? How to discern what that subtle thing between a Mark Hopkins and the student at the other end of the log is, and to strengthen it and use it more effectively? How can I make myself a better teacher?

How?

The freshman comes to college with a curious lot of knowledge and more curious lacks of knowledge. He has but recently passed adolescence and in many cases is making his first venture away from home and his home town. He is the raw material which the college, the engineering school is, in four or five years, to turn out with some additions to his

knowledge of facts and training of his mind and hand so that he can fit into the engineering work of making nature serve man. His knowledge and preparation for the particular subject of drawing is as varied as the individual; a few are quite proficient, but many have never seen a drawing instrument before. Except the few cases who have had vacation experience in drafting rooms they have no notion of the commercial aspects of making mechanical drawings.

As stated mechanical drawing is a language, it tells things, is a means for conveying ideas. C. R. Dooley stated it, "A mechanical drawing shows plan view, orthographic not perspective. Top, bottom, end, and side views may be made, each on a different piece of paper and to a different scale. One view may be a blue print, another may be a pencil sketch and a third a chalk sketch on the floor, yet the whole is a perfectly good mechanical drawing. Merely for convenience we have adopted certain standard conventions such as all views to same scale, all views on same sheet, all views arranged on the sheet in their natural relation in the piece.

First of all a draftsman must think intelligently in terms of mechanical pictures, then of course he must master the technique to be understood by workmen who are to use his drawings. There are some men who take off their hats to a blue print when they see it. To them it is a sacred document."

In teaching mechanical drawing one must thus train the mind and the hand, the mind to perceive, to think, and the hand to execute.

Thorndike states the work of teaching to be "to produce and prevent changes in human beings, to preserve and increase the desirable qualities of body, intellect, and character and to get rid of the undesirable. To thus control human nature the teacher needs to know it."

"Using psychological terms, the art of teaching may be defined as the art of giving and withholding stimuli with the result of producing or preventing certain responses. In this definition the term stimulus is used widely for any event

which influences a person—for a word spoken to him, a look, a sentence which he reads, the air he breathes, etc. The term response is used for any reaction made by him—a new thought, a feeling of interest, a bodily act, any bodily or mental condition resulting from the stimulus. The aim of the teacher is to produce desirable and prevent undesirable changes in human beings by producing and preventing certain responses."

Sharpen the perception so that the student really sees what he looks at, have that perception start mental processes or reactions which accumulate into thought giving a mental picture of what is desired and then parallel with this the training of muscular control so that the lines of the drawing may be put down as the concrete visible execution of the mental picture, these are the aims. The training of perception is done somewhat in other courses but the training in motor control, in muscular skill, to handle the instruments skillfully is the burden of this course. It requires practice, practice, practice to acquire this skill in drawing.

The specific problem of the teacher is to make these changes as economically and as surely as possible under the conditions of the drafting room and lecture room. He must give certain information, elaborating what textbooks may say, must get the students to form correct habits, increase their powers of observation, arouse their interests and inspire their ideals. If he has had practical commercial experience in his line in bumping the cold hard world, it is a fortunate class indeed, for he brings in the atmosphere they will have to work in when they graduate and can give an inspiration and certainty to the work. This knowledge and the power to handle it breeds interest in the student and inspires him to work, and as he proceeds and succeeds, to increase the interest and satisfactions of doing it.

Thorndike in the chapter on Motor Education in his "Principles of Teaching," states the ideas as follows: "The principles of teaching form are those of intellectual education generally modified to meet certain special facts. The

student needs to be interested in the work, to attend to the instructions and examples given, to understand and remember directions, to be given practice in following them and to be rewarded when he does; explanation, example and drill must be all suited to his natural tendencies and previous experience. The chief modifications are three. Two of these are due to the fact that the idea to be gained is usually one of a complex position of the body. Hence example is far better than rule, imitation more effective than explanation and the formation of abstractions is rarely necessary or useful. Only concrete thinking about the particular things is required. The third modification is due to the fact that the things to be put together (in habit forming) are certain ideas and certain muscular acts and that consequently the essential thing is what the student does. Learning how to hold the pen must include actually holding the pen.

"There are two dangers however, first, neglect of imitation; second, exaggeration of the importance of some particular way of doing a thing.

"The principles of teaching execution are those of habit formation in general modified as to the particular nature of the conditions—connections between situation and movement direct—as may be required. The important modification is due to the fact that the teacher is less able than in purely mental connections to put together the things he wishes to have go together.

"In teaching execution then, the vital principles are (1) fitness to capacity, (2) interest, (3) abundant practice directed by proper instruction in form, and (4) the rewarding of good tendencies."

How can I do this? How can I make myself a better teacher?

Well, what is a good teacher?

The author will confess that his experience in teaching is too limited to answer that question. It is several years since he sat in a class as a student and the intervening time has

been very busily occupied and his memory of his teachers has been pushed into the background, so he cannot write much from the memory of them. However, he can check up his ideas with what men of long experience in teaching and who are regarded as successful teachers have set down about the things which make a good teacher.

W. F. Magruder in a paper on "The Good Engineering Teacher," says: "He is one who knows enough of his subject to have something to impart, he is one who has learned one of the essential requirements of the successful engineering teacher, namely, to have rubbed elbows with working men of the artizan type and to have measured himself by their standards of knowledge and skill. He must be one who can talk on his feet audibly enough without effort to be understood without subsequent correction. He has an unimpeached and deserved reputation for mental honesty, right living, patience under harassment and sound character. He has unbounded enthusiasm for and intense loyalty for the work of the teacher and of the engineer, he never counts the cost to himself of his labor for those he loves to call 'his boys.' Akin to enthusiasm for his work is his inspirational value to his students and his colleagues in the faculty. He is not ashamed of his job and feels the thrill of being engaged in upbuilding character. He is above all things a good engineer. Good teachers must be first able to impart their knowledge, draw out from their students all that is in them and cultivate in them habits of correct thinking, clear vision, active imagination, sound reasoning powers and good judgment and because they possess these things themselves and can train others in them they are therefore to be counted good teachers. To be a good engineering teacher one must be something of a scholar, student and creator, and highest of all an educator capable of leading others to be the same."

F. E. Spaulding in his paper "Three Characteristics of a Good Teacher" says: "1. A good teacher is a good student. 2. A good teacher teaches his students to study effectively

the subjects of instruction and 3. A good teacher assumes a large share of responsibility for the failure of his students."

Horne in "Psychological Principles of Education" says: "The teacher must have a knowledge of the subject, must know much to teach a little. Knowledge begets enthusiasm, self-confidence, gains the respect of the class and gives the right perspective. Know your students, recognize them, and call them by name. Must have ability to teach. This comes from two sources, heredity and training. The great teacher is born but he can be improved by training."

Charles E. Chadsey in his paper on "Teaching" says: "The following four points are fundamental in the technique of engineering teaching:

"*a.* Sufficient scholastic and technical training.

"*b.* The power to impart to his students through the medium of his instruction the necessary knowledge demanded by the curriculum.

"*c.* The ability to supervise the actual work of the students and to recognize and direct their intellectual activities in such a way that real economy in intellectual effort is the product.

"*d.* The possession of qualities on the part of the instructor which will enable him to inspire those who are working under him and to develop on their part a genuine enthusiasm and not infrequently a real love for the subject which is being taught."

Carl Herring in his paper on "College Education of an Engineer" wrote: "Success in teaching can be properly measured by the interest the teacher can develop in the mind of the student."

Summarized in my own words, a good teacher is one who teaches good, one under whom the students learn. He knows his subject, a mile for every inch he tries to teach, he has a genuine conviction that his subject is a useful contribution to the advancement of civilization, there is some point to it. He has the art of getting his students interested in the sub-

ject, which perhaps is the essence of the subtle bond between the student and Mark Hopkins on the log; he has the respect of his students outside of the classroom and also the respect of the community; he will have training in the art of teaching as well as in his subject.

A large contract indeed to be all the foregoing! These are the specifications of a good teacher. The next question is hard by—How can I make myself a better teacher?

If teaching is an art and teachers are born, not made, one is in a bad fix for he cannot go back and choose his grandparents. However, such rudiments of the art as he may have can be trained. To answer the question in the first person, I can study my subject, I can keep up with the advance of the art in that line, I can make myself a better draftsman, I can keep up with the general engineering advancement and of the world, I can study my students, for it is as true now as when the poet wrote it, "The proper study of mankind is man," study psychology, study pedagogy, get into the minds of the students and see their point of view and use this to get their interest in the subject, try to inspire my students, study and improve my ability to impart my knowledge, improve my character, easier said than done, for if character be the crystallization of a will, changing that is the work of a lifetime. Not merely studying students, study myself and the whole art of teaching, not forgetting to avoid the danger of schoolmastering myself.

Study the art of teaching, study my students, study myself.

Remember the freshmen are only learning to creep and give my best efforts to help them, help in a way not to weaken.

THE SCOPE OF GEOLOGIC TEACHING IN MINING ENGINEERING.

BY C. L. DAKE,

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In the past, scope of subject matter and method of presentation of engineering branches have not received adequate scientific consideration. Recently there has been much discussion and revision of curricula in engineering schools, unfortunately with but small agreement as to what is truly fundamental in engineering education. The present paper proposes to deal with only a very small part of this field—the teaching of geology to mining engineers.

Starting with the generally accepted thesis that geology should hold some place in every mining engineering curriculum, consideration should first be directed to the number and character of the courses given, then to the subject-matter to be covered in each course, and finally to methods of presentation.

A study of the catalogs of several mining departments shows that there is wide divergence in view as to the proportion of time that geology should bear to the whole curriculum. Since the latest catalogs were not always available, and inasmuch as various systems of counting credits are in use, the following tabulation represents only a fair approximation. Only metal mining curricula were considered. Where geology options are offered, these, of course, include more geology.

PERCENTAGE OF GEOLOGY TO TOTAL HOURS IN VARIOUS METAL MINING CURRICULA.

Arizona	13.1	New Mexico	19.1
California	13.6	Oklahoma	9.8
Colorado	11.2	Pittsburgh	8.6
Illinois	6.2	South Dakota	14.1
Mass. Ins. Tech.	8.8	Utah	11.2
McGill	11.6	Washington	13.8
Missouri	9.4	Wisconsin	6.6
Montana	16.7	Yale	14.6
		Average	11.77

It will, of course, never be possible to reach any very close agreement on the figures presented above. The attitude taken by leading educators in the mining world, as well as by prominent practising engineers, will depend to a very large degree on the quantity, and the quality, of the geological training they themselves have had.

If, in the future, geology is to justify itself in mining education, and develop an increasing importance, and demand a greater respect among mining men, there must be a greater effort among its teachers: first, to make instruction more thorough, and second, to direct it more specifically toward mining needs.

In order that this may best be accomplished, it is necessary that those who instruct our young mining students in geology should know enough about mining work, and mining terminology, to talk intelligently with mining men, to point out the applications of geology to mining students, and to impress them with the value and accuracy of the instruction they are receiving.

That a knowledge of music, of painting, of the social amenities, may add, not only to the pleasure, but also to the success of the engineer—*provided he is fundamentally a good engineer*—is hardly open to question. However, that there must be a limit to the deliberate teaching of so-called cultural subjects to engineers is also open to no question whatever. The fact that engineering schools exist as such, entirely apart from other institutions of learning, if such schools are justified at all, justifies us in teaching all subjects there presented in such manner as to directly further engineering education in the broadest sense.

This is as true of geology as it is of any other branch of learning. This principle, however, can never be made to justify slipshod methods and rule-of-thumb procedure. Whatever of the subject is worth teaching to mining men at all is worth teaching well. If the men are really to profit thereby, they must not simply be fed up on facts and defini-

tions; they must understand thoroughly the underlying principles, and learn to think in terms of geological processes. It is in this particular that much geologic teaching—in fact, much of all teaching—is sadly defective. The facts are in the text book, where the man can find them at any time, but he must learn to think from and through those facts, to his chosen profession. It is here that the textbooks and even many instructors, fail. It is here that the efficient teacher is needed—a man who, from his own personal knowledge and experience, can and will point out the distinction between the incidental and the fundamental in the common ground occupied by geology and mining.

The proportion of time that geology should bear to the whole curriculum will be determined in different institutions in various ways, but never will the department of geology have more than a suggestive voice in the matter. This is perhaps no more than right, since there is always a tendency for any department to magnify its own importance.

It would seem, however, that ten per cent. of time allotted to geology approaches the irreducible minimum for a truly well-balanced mining engineer, but in the present article we are less concerned with the quantity, than with the quality of geologic instruction—the latter being wholly in control of the geological department itself.

Being alotted a certain amount of time, the department is usually allowed considerable latitude as to the division of that time into courses, and is almost wholly in control of the subject-matter and the degree of coördination of these courses.

Experience shows that mineralogy, general geology, and economic geology are usually considered fundamental. Either as part of these, or as separate courses, is very generally included instruction in lithology, map interpretation, and field mapping. In one form or another, it is believed that all these should be included. For those schools that allow considerable latitude in regard to electives, more highly specialized courses may well be offered, such as advanced structural geology,

petrography, advanced map interpretation, advanced field work, geology of oil and gas, stratigraphy, or the like; but it is doubtful whether any of these should be required, except where a special option in geology is allowed.

In a study of this sort, it seems eminently worth while to examine each subject separately, with a view to determining its proper relation to the other courses, its subject-matter, and methods of presentation.

Mineralogy.—In subject-matter, at least, the courses in mineralogy do not appear to differ materially in the various institutions. Whether mineralogy should precede, accompany, or follow general geology, seems to be a matter of varying opinion.

An examination of 17 mining curricula shows that 6 place mineralogy first, 5 place general geology first, and in 6 the two subjects are taught at the same time. After experience with both methods, however, the writer has come to the firm conclusion that to teach mineralogy first, followed by general geology, forms the best combination, requiring the least duplication of teaching effort. A considerable knowledge of mineralogy is absolutely essential to the teaching of a thorough course in general geology, such as is really suited to the needs of mining men, and mineralogy, if not required as a prerequisite, must be taught by the man giving the geology. If the mineralogy is taught first, it gives the man teaching the general geology an opportunity to spend more time on the presentation of engineering applications.

In most general colleges and universities, it would seem that neither course is demanded as a prerequisite to the other. It would be interesting to know in how many schools there is a real sentiment in favor of making general geology a prerequisite for mineralogy.

Most courses in mineralogy have been prefaced with an elaborate study of crystallography. It is beginning to be realized, however, that crystal form is less important than many other properties in the common recognition of minerals,

and in some quarters mineralogy now includes only such teaching of crystallography as is of definite value in identifying minerals without the microscope—the more detailed study of crystals being required only of those who elect to take petrography. This, while it appears to be a decided step in the right direction, must not be overdone—some knowledge of crystallography being essential. As a result of this procedure added drill can be given in sight and blow-pipe determination, in discriminating between minerals that closely resemble each other, and in mineral associations—a subject that ought to be of great interest and importance to mining students.

Mineralogy does not lend itself to a variety of methods, the content of the course being rather rigidly circumscribed. There seems to be some question as to the proper relation between lecture and laboratory time. Experience seems to show that the greatest weakness is lack of drill, and that lecture time can well be cut to a minimum, with added stress on laboratory work. In fact, there is some argument in favor of giving the necessary lectures in laboratory time, thus allowing a closer coördination between the descriptive and determinative work, and assuring that the discussion will be followed immediately by the appropriate laboratory exercises.

To get the best results, frequent quizzes are essential; and those given orally to groups of two or three men at a time, with insistence that each man pass each mineral group creditably before going on with the next, seem to be most effective. This, of course, demands an adequate teaching staff.

The laboratory work should not only include blow-pipe, but should also involve much study of known and unknown sets, under competent guidance, with extensive drill on sight recognition, accompanied by insistence on ability to tell how certain similar minerals are told apart, to give common mineral associations, and to describe uses, importance, type of occurrence, and well-known localities.

The time devoted to mineralogy should probably not be much less than one fifth of the total time allotted to geological subjects, and the proportion should be larger, if the total time for geology is very small, as mineralogy is really the most fundamental, in the immediate and narrow sense, of all the geological branches taken by the mining man.

Lithology (Petrology).—The naming and identification of rocks is, in some schools, studied as the finale in mineralogy; in others, it is carried on in connection with the general geology, while in still others, it is cared for as a separate course. If given as a separate course, it necessarily follows mineralogy, and may conveniently be made to accompany general geology. This appears to be the most satisfactory arrangement. Such a course consists, properly, of a study of the origin of the various kinds of rocks and their identification, megascopically. The only difficulty in deciding on subject-matter here will usually apply to the igneous rocks. It is hard to know what degree of refinement to expect, in the very intricate classification of this group. Limitation to strictly megascopic identification appears to be the safe stopping place. Such a course will properly include the general principles of sedimentation, magmas, and metamorphism. If this and the course in general geology are required of the same group of men, as they should be, and particularly if taught by the same man, they can be closely coördinated. If not taught by the same man, the two men should each become familiar with the course the other is giving, to avoid unnecessary duplication, or discrepancies of subject-matter.

This work should consist of both lectures and laboratory exercises; and again, the prime element is repeated drill on sight determination, with both known and unknown sets, followed by numerous quizzes, preferably oral, two or three men in a group. Insistance should, as in mineralogy, continually be placed on the methods of discrimination between similar types.

The time allotted to lithology will vary greatly, but will

probably usually be considerably less than that given to mineralogy.

General Geology.—The course in general geology is, of all the courses usually given in the department, the one most subject to diversity of treatment in various institutions. The writer has given more time and thought to this course than to any other, and feels that, so far as proper training in geology goes, this is the course that should set the standard. It is here for the first time that the student begins to think in terms of geologic processes. Mineralogy and lithology are fundamental, but they are the figures and the alphabet. It is in the course in general geology that the student first begins to read the science. It is here, of all places in the department, that greatest care, both as to subject-matter, and method of presentation, should be taken. If the student begins to think, here, in slipshod way, his geology is likely to be slipshod through the rest of his career. The best teacher in the department (not necessarily, however, the most learned man, or the best field geologist) should handle this course. There is probably no other course that makes such a demand on the teacher, or that is so fundamentally important.

After considerable experimentation, the writer's present course is divided as follows, one half the year to dynamical geology, one fourth to structural, and one fourth to historical and stratigraphic geology. It must be understood, of course, that mineralogy is a prerequisite, and lithology an accompaniment.

In the presentation, practical applications are used frequently, as the surest way to hold interest. However, the teacher should be at no little pains to show that other than directly practical things are worth while, that the purely theoretical of today may be the intensely practical of tomorrow. Geology does not lack for illustrations of this principle. In the effort to point out practical applications, and make the course usable, great care must be taken not to depend upon purely empirical data. Herein lies a tempta-

tion to which the teacher too often succumbs. Geology is a science that demands to an unusual degree, not only keen observational powers, but a high development of interpretative ability. Every problem contains new elements, and rarely can rule-of-thumb methods be depended on for reliable results. For this reason, it is imperative that processes and principles be understood, so that deviations from the familiar may be solved. Too much stress cannot be laid on the fact that to be practical does not mean to be empirical; though, too often, the word "practical" is so interpreted.

All teaching of geology should be aimed at developing the power of independent judgment, the ability to solve a problem not quite like any problem ever studied in the class room, or met elsewhere in the field. No man can be a real success in geology, who has not, to some extent, developed this power.

In fact, it is firmly believed that the question of whether or not a man has developed such ability should determine largely whether or not he should pass the course, much more largely than his mere absorption of facts. In other words, examinations should be so framed as to test power, not memory; and to this end, problems never discussed in class should be utilized—problems, of course, depending on principles already studied, but with some new factor which will dress them up in an unfamiliar guise.

In the study of dynamical geology, in the writer's course, emphasis is placed quite differently than in the usual standard course in general geology in so-called cultural schools. Nevertheless, it is believed the course as given will yield the student as much culture (*i.e.*, ability to get pleasure out of his surroundings, to understand and interpret what he sees) as will the average course.

Most controversial matters, as well as pure hypotheses, are avoided, or treated lightly. This is not with the feeling that these matters are unessential, but rather with the idea that, in order to cover a wide field in a limited time, more essential points with quite as great training and cultural value are to

be preferred to subject-matter less pertinent to the mining engineer's special field.

It may be wise to repeat, at this point, that such a selection should in no wise be allowed to lead to disconnected presentation of mere facts, no matter how practical these may seem. The interrelations between the various parts of the subject, the unity of the science, and the *close relationship of cause and effect* must everywhere be emphasized, and the student must learn to *think* the new science. A judicious use of lantern slides adds greatly to the interest in the course, and leaves a vivid impression not possible to give by the formal lecture, or printed page.

Accompanying the course in general geology should be laboratory work. In all cases in which mineralogy precedes general geology, and in which lithology (petrology) is given rank as a separate subject, the laboratory should probably be pretty well centered on map interpretation and field work.

The importance of the course in general geology demands that adequate time be given to this subject. Probably not much less than half the time usually allotted to geologic branches as a whole should be given to general geology, and accompanying laboratory.

Field Work.—Field work will naturally vary greatly with local conditions, but should comprise at least a small part of every course in general geology. So far as possible, men should be taken out in small groups, as very large classes are very hard to handle in the field, and are likely to become more or less of a farce. What should be done in the field will depend so much on distance of travel, local geology, and available time, that few definite suggestions are desirable.

The writer himself is thoroughly convinced that all mining engineers should be required to take at least a month's summer course in field geology in camp, under ordinary working conditions, in some moderately complex area. In few schools is it possible to have more than half day periods

open to field work, and in few are there really suitable areas within reach of half day trips.

Economic Geology (Ore Deposits).—Following the course in general geology, which should certainly be regarded as a prerequisite, most mining curricula finish the geologic training with a course in economic geology, which usually lays stress on the metallics, and is not uncommonly titled "Ore Deposits." Regardless of locality, such a course should begin with a thorough study of general principles of water circulation, vein formation, paragenesis, and closely related topics. These will be followed by studies of special districts, considered as illustrations of the above principles. The districts chosen will depend to some extent on the experiences of the man giving the course, and on the location of the school—though certain districts are almost invariably studied as types.

The subject-matter of this course is not open to as great a variety of treatment as is that of general geology. With mining students—for the most part, undergraduates—a good text is probably advisable, but this course should begin the habit of going to original sources, such as State and National surveys, scientific journals, etc. In fact, much of the study should be from such original sources. Good illustrative sets, not only of ores, but also of associated rocks, are highly important, and should be freely used as illustrative material in lectures, and as the basis of laboratory studies, if time permits.

It is not believed that many other courses than those described above should be required indiscriminately of all mining engineers. These, taught thoroughly, are better than more, spread more thinly. For men taking a mining geology option, such courses as stratigraphy, petrography (microscopic work), advanced structural geology, and paleontology should be added to the requirements; and regional geology, topographic sketching, geologic mapping, etc., are desirable electives.

MEMORIAL TO THE BOARD OF INVESTIGATION AND COÖRDINATION.

The Kansas-Nebraska Section in session October 28, 1922, with fifty members present extends greeting.

We approve the plan, and welcome the moment to coöperate with all existing organizations in the endeavor to establish more effectively the avenues of contact between engineering graduates and the industrial organizations of the country.

We believe that movements to improve and develop our school curricula should be based upon the results of investigations as to the developing needs of industries.

We further believe that our Society should bend its efforts toward the perfecting of our teaching methods, and the training of men in such methods, especially to the end that our teachers may be prepared to reflect the highest standards of the engineering profession to their students, and so far as consistent, instilling the spirit of industrial activity into the subject matter taught.

We favor the rounded out curriculum, with sufficient attention to subjects of general nature to open to the student a vision of his possibilities as a useful member of society; in this believing that this aim may be attained in good part by the effective presentation of engineering matter by our own teaching staffs.

Representing the three schools of this Section, we pledge our support to the Board of Investigation and Coördination and extend a cordial invitation to it to visit us at its convenience.

Signed:

P. F. WALKER,
President,
C. W. SMITH,
Secretary.

MEETING OF THE KANSAS–NEBRASKA SECTION, OCTOBER, 1922.

The Training of Engineering Instructors.

Geo. C. Shaad,

University of Kansas.

I have been asked to introduce the topic of the training of engineering instructors for discussion at this meeting. This I am very glad to do, realizing that the responsibility of definitely settling the question as to just how such instructors should be trained does not rest with the one introducing the subject.

We believe that teaching is a profession and we have established our Normal schools, primarily for the training of teachers of the common branches, and have introduced our departments and schools of education in our colleges and universities to prepare teachers for our high schools. Applicants for positions as teachers in our modern high schools must present evidence of special training in educational subjects and must have had at least a prescribed minimum of teaching practice before their application will be considered. When we come to the selection of teachers in our colleges and engineering schools, however, the possession of a certain degree, whether or not the studies in preparation for that degree involved any "educational" material, and generally irrespective of whether the candidate has had actual teaching experience, is all that is required of the young instructor. In engineering work the bachelor's degree is the usual requirement.

The extent to which college and engineering teachers should be prepared in purely educational subjects is one phase of our topic which I would like to have discussed by our representatives from the educational departments.

The usual practice then, in our engineering schools, is to

select our young instructors from recent graduates from engineering schools, perhaps with a limited amount of engineering experience, selecting them for personal characteristics as well as scholarship, and then training them, or allowing them to be trained, after they have entered the profession. In many cases they are given the name of the subject and the schedule but practically no instructions are issued as to the detailed manner in which the teaching is to be conducted. Perhaps this is an excellent method. Nothing develops ability so rapidly as actual responsibility provided the work involved is not too far in advance of one's training and experience. However, I believe that most of us will agree that a little more attention to the direction of our younger instructors would show considerable returns upon the effort.

What, then, are some of the things which we should do and which we should encourage our younger men to do in the interest of improving their teaching ability? The following are random statements of some of these things as I see them, with no attempt to make the list complete or to place them in the order of their importance.

First: Engineering training, or at least a general knowledge of and sympathy for engineering applications, should be required of an engineering teacher. This is self-evident in the case of teachers of the technical subjects, but I would carry it on into the allied subjects of mathematics, physics, and even English, if you please. Were it possible, in the limited time available, to carry our students far into the fields of chemistry, physics, literature, history, etc., then the contact with teachers who may have no concept of the engineering field would perhaps have definite advantages but, with the time limited, I do not believe our men suffer much from the purely cultural standpoint and they profit materially in other ways from teachers who have fairly definite knowledge of the way in which their subject contributes to the training of an engineer as such.

Second: The teacher of technical subjects should have practical engineering experience to the extent that he has been

responsible for important work or develoments. This experience, in exceptional cases, can be secured during the teaching period and during the summer vacations but, as a rule, it takes at least two years of real contact with the engineering field. I feel this point so strongly that, in my own department, I have the general rule that I will not retain a young engineering graduate beyond two years, feeling that, if he is to continue in teaching, he should have intimate and extensive engineering contact before going on with his teaching and, if he is not going into teaching permanently, it is time he were starting in what is to be his future work. Changes of instructors on account of this rule often subject the department to some inconvenience but we believe the individual benefits.

Third: We, as responsible for the departments, should keep in reasonably close touch with the work our instructors are doing and be helpful with timely suggestions and directions. We may even take these men into our own classes or arrange to have them visit classes of other engineering teachers where we have reason to believe they will profit by a study of the teaching methods of other instructors.

Fourth: We should carry the matter of visit of classes and study of teaching methods outside of our own schools and provide for our men to visit other institutions purely for the purpose of studying department organization, equipment, and methods of instruction.

Fifth: Young instructors should be encouraged to keep in contact with the engineering profession. Membership in our national engineering societies should be kept to the highest grade for which the instructor is qualified. The instructor should be a member of local engineering organizations. That he should be interested enough to associate himself with the S. P. E. E. when he has the opportunity to benefit directly from meeting of sectional branches goes without saying. Not only should the instructor keep up membership in engineering societies, but he should attend conventions and meetings and take active part when this is practical.

Again, the instructor should keep in touch with the engineer-

ing field and the persons engaged in the practice of engineering by the doing of actual engineering work. A limited amount may come from problems submitted to the school with which he is connected but the greater opportunity is afforded through summer vacation work and the summer courses for engineering teachers as offered by some of our large manufacturing companies.

The above is offered as an introduction to our topic and I am sure that the members and guests here assembled will add materially to this list and bring out what is good and what is bad in a completed outline of what should be done in the matter of the training of our engineering instructors.

Additions to our Curriculums.

O. J. Ferguson,

University of Nebraska.

The report of the Development Committee of the S. P. E. E. August 8, 1922 uses this sentence: "The problem of Engineering Education is to determine and to meet the progressive demands of a rapidly changing civilization." It further states that in determining what the engineering graduate should he "it will be necessary to study the functions of the engineer of the past and of the present; and to try to conceive those of the future, keeping in mind the highest ideals of service to be rendered the public and the profession."

In determining what the training of the engineer student should be, "It will be necessary to define and express as clearly as may be those high and comprehensive ideals of service, . . ."

You are aware that the committee has recommended that a Board of Investigation and Coördination be created within the society to direct the study toward the ascertaining of the facts of engineering education, and the present and future requirements in fields served by engineering students. In this the coöperation of engineering schools is sought.

The report is an epoch-making document, for it initiates as a practical investigation a broad survey which will have far reaching effects upon engineering education. It is notable as an expression of our loftiest ideals for placement of the engineer in his proper field of service; as a clear statement of our educational problem; as a logical recommendation for coördinate action that is necessary to the production of the desired results.

We have all been working in our individual ways to promote engineering education. We have coördinated our efforts whenever and wherever we could. But our studies have not been comprehensive enough to give us the greatest results. Many questions remain to be answered, as to aims, processes, methods, materials and even evaluation of the results. But in the meantime, we feel that we may progress perhaps by definite steps in any direction indicated by a strong concensus of opinion. It is to comment upon one of these propositions that I am here tonight—the inclusion of new subjects in a longer curriculum. What shall these changes in the curriculum be?

An analysis of the situation convinces us that the answer to the question is bound up in the solution of several other queries. Not until we can reply satisfactorily to these latter can we proceed with assurance to the answers of the former.

(1) Are our average engineering graduates now prepared for the work which they are expected to do?

(2) Do the limitations of their training inhibit them from entering proper and desirable fields?

(3) In what ways will the demands upon future engineers differ from those made upon the present engineers?

Speaking of technical training, I am convinced that the present college course, when well utilized, is a sufficient introduction to the field of engineering to admit the student to a direct and growing participation in the engineering activities of our communities. Comments made by employers assure us that the new graduate comes to them with a satisfactory training of this sort. Young engineers "find them-

selves'' quickly and orient themselves to their work without much loss of time or effort. Technical skill seems to be available of sufficient acuity and vision to meet the common needs of modern civilization. Even the great technical engineering problems find solutions when they are demanded, and not infrequently the realization of a project delays long after its practicability has been established.

Moreover, the present-day engineer is progressive. He is quick to see the changes brought about by new conditions and novel developments. He adapts himself to this growth, perceives the new problems and promptly sets for himself the task of their solution.

With the average new graduate, however, the term ''engineering'' is given a narrow technical interpretation. When asked what line of work he intends to take up, or when observed as to his tendencies and preferences, he most generally indicates a leaning toward manufacturing, erecting, construction or operation of engineering machinery or the poorly comprehended thing known as consulting engineering. During this early period of study and training, the lad measures his development wholly in terms of mechanic arts.

Much less frequently is the student influenced by the idea that he is preparing to become a manager and that he will handle men; that he will determine the financial policy of his company. And never once does he harbor a suspicion that he will be forced clear outside of technical engineering into problems of group psychology, international law, foreign trade relations, method of financing projects, public utilities, stocks and bonds, cost accounting, hard times, etc.

To repeat, I believe that the student is sufficiently trained in technical engineering subjects to permit him to enter into the work open to him upon graduation and that he can grow in this type of experience as rapidly as his duties become more exacting. However, for the non-technical activities, I doubt the efficacy of the preparation.

We thus come directly to the second question, as to in-

hibitions. Is the engineering graduate prepared by his college course to assume the larger duties of men in industry? Or is he even assisted in this process? Or, worse yet, is he impeded? "But," some one says, "why worry? Only a lesser number of our men need to be prepared for these duties—so why coach them all for work which many will never see, much less comprehend?" And, right here, we may as well agree that the five-year course is not for all students. But we still assert that the type of course good for a five-year student is also good for the four-year student. More will be said of this later.

One classification which may be used in comparing the effects of studies upon the mind is that which places in one group all subjects which suggest the possibility, the practicability and even the desirability or necessity of exact solutions and final answers; while in the other group we place debatable theses, hypotheses, philosophies, interpretations, opinions. The one group trains in accuracy, reliability, finality; the other in caution, self-reliance, invention, tolerance. The one demands machine-like precision and the elimination of the human factor; the other recognizes the personal element as present in all things as a most important factor and variable. If the content of our curriculum is wholly of the former type, we stunt the imagination and tend toward standardized workmanship. We lose the clear-headed conception of social bases. We gain the precision of a cast bronze statue—and lose the life of the chiseled marble.

But if the new graduate now fails to measure up to the opportunities which might be his if he were a more social being, what of the future? Certainly the demands for large men to fill large positions will increase rather than diminish. The complexity of civilization is increasing; new responsibilities arise; new creations are demanded; new crises must be passed. Capital and labor must learn how to court rather than antagonize each other. Accumulated wealth and acquired power must learn the lesson of responsibility and stewardship. Unemployment must cease its wasteful drain.

Production must keep pace with consumption. Stability and order must take the place of chaos. Coöperation must replace independence. Conservation must displace waste in industry.

If the engineer is to take his place in these Herculean tasks, he must be better prepared than ever. He must know not only processes but economics. He must know not only things but men.

It is rather startling with what unanimity certain additions to his training are suggested by men who have studied the engineer. Such are foreign languages, economics, including finance and statistical methods; english both written and spoken, psychology, history, law, administration and management. Why should these titles appear so persistently in our lists? Are they accounted for by pure utilitarianism? Let us look at some of them.

Foreign languages involve translation from English into another language. This requires (*a*) an accurate analysis of the sentence; (*b*) the apprehension of the idea; (*c*) the synthesis of a statement with new vehicles of thought. What can lend itself more effectively to clarity of thought processes and definition of ideas?

History, if studied rightly, is human beyond all other qualities. Its value as a record of events sinks into insignificance in comparison with its worth as an index of man's character.

English, the richest language of all time—so complex and yet so direct, so vigorous and yet so delicate—so sufficient and yet so scantily used—so capable and yet so abominably misused! What wordy discussions we have heard because of some difference of opinion as to the meaning of an important sentence. If we should use the English language really *well,* one half of the disputes of Christendom would disappear!

Economics—the science of values, basic to all applications of engineering principles.

Finance—applied economics.

Law—the sifted dictums of the past centuries.

Psychology—the science of thought processes.

Why do these appear in our lists? What a needless question!

Could not a four-year curriculum be bettered by the inclusion of some of these studies? If their insertion crowds out necessary engineering matter, is there any escape from the longer course?

And, finally, would I suggest that the five-year course—aye, even the four-year course—be so laid out that we may let the student think. Give him time and proper inducement to think. Let him know we desire it of him. We expect him to learn—but much more should we expect him to think. The greatest engineering problems are not solved with a slide rule.

"TRAINING MEN FOR INDUSTRY."*

BY V. KARAPETOFF,

Cornell University.

The first diagram emphasizes the importance of *continuity of effort* and of *patience*. After graduating from a technical school the young man should select some particular branch of electrical engineering and carry it through life as a *thread*. The speaker compared the process of becoming proficient in a subject to that of spinning a thread, adding to it new fibers

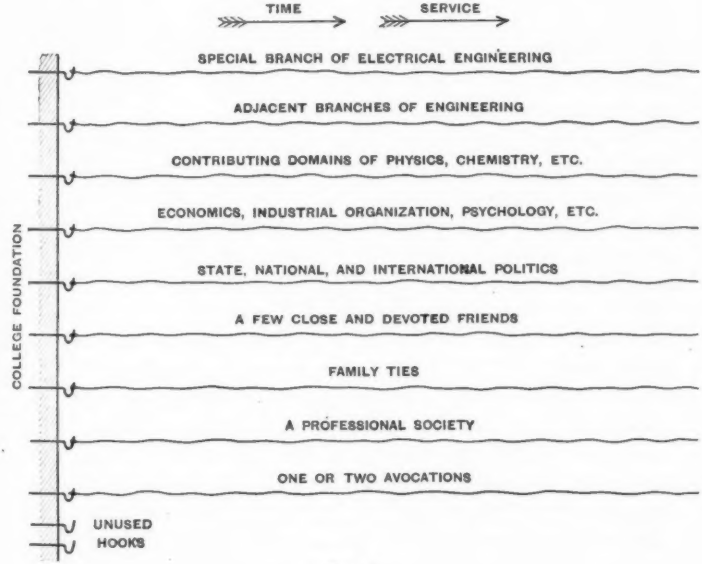

FIG. 1.

* Address given to Engineering Apprentices, Westinghouse E. & M. Co., East Pittsburgh, Pennsylvania, January 16, 1923.

as opportunities present themselves, and working these fibers organically into the thread. Only in this manner can a young man hope to become a master of the intricate details of an electrical subject.

However, it is not sufficient for success and for happiness to be a narrow specialist. So the remaining lines in the diagram show some other "threads" which a normal and harmoniously balanced young man should tie on to his college education and learn to spin them continuously through life. The speaker said that the usual claim of lack of time is mainly due to impatience and to the lack of continuity of effort. One who lays out his problems for many years to come, can always find at least scraps of time, periods of low demand, unused intervals, etc., to add a few fibers to this or that thread. The two arrow heads on top are intended to indicate the continuity of the threads and the ultimate purpose (service) for which they should be carried on and which alone can give true and lasting happiness.

In Figure 2, the difficulties in spinning one of the main threads are illustrated in the manner of climbing a hill, like "Pilgrim's Progress." At *o'* the young man starts with but a small amount of knowledge, *Oo'* (residual magnetism) acquired in college. On the elementary stage *o'a* he cannot work very hard because he has to rely on others to help him, and he cannot do much original thinking, not having enough facts to base it on. Between *a* and *b* is the first real climb on which many fail and either remain routine drudges for life or are deflected into more congenial occupations. Most of these find later on that in their new occupation they will some day stand before a similar steep climb *ab*. Those who succeed in reaching *b* usually have several opportunities of applying their newly acquired skill and knowledge, and thus make this skill an organic part of their personalities. This period, *bc*, the speaker called the period of *assimilation of knowledge*.

After this, the successive stages of a man's professional career may be represented as a succession of climbs requiring

a large amount of hard work coupled with original thinking, and of periods of application or assimilation. The cross at *e* stands as a warning to those who have spent the best parts of their lives in climbing to a certain position or recognition, only to find at the end that either their vision is insufficient to climb the last rock or that they are not any more capable of even a moderate amount of required hard work.

A few who reach *f* cannot rest on their laurels, but, having become leaders in their profession, have new responsibilities which such a position implies. The speaker indicated two kinds of duties of high leadership. One is to help others to climb as high as possible. This duty is indicated by posts s_1 and s_2 to which ropes are attached and thrown back to various steep slopes. The other duty is toward future unborn generations, to open new vistas for them and to make their life paths easier and more fruitful. This duty is indicated by the arrowhead marked "Infinite Progress."

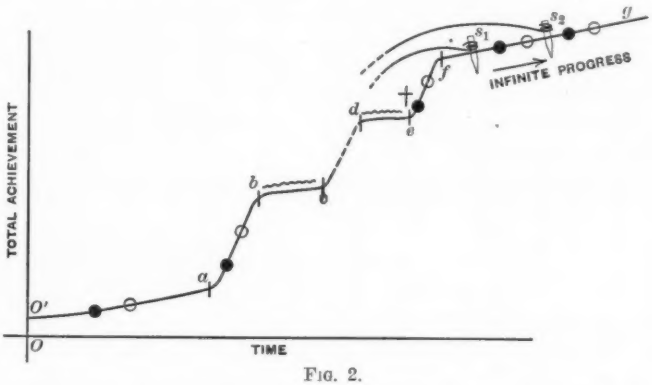

FIG. 2.

●, hard work; ○, original thinking; ∿∿, assimilation; †, the common grave of "almost successes"; s_1, s_2, posts with ropes to help climbers.

COMMITTEE NO. 16, MECHANICAL ENGINEERING.

To our Fellow Members of the S. P. E. E. Who are Teaching M. E. Subjects:

President Charles F. Scott has injected some of his own $\frac{1}{2}$ Mv^2 virus into the Society's Committee on Mechanical Engineering, hence this letter.

It is desired that in each monthly Bulletin of the Society shall be published short, one half page or longer, snappy papers, preferably illustrated, descriptive of new teaching methods in mechanical engineering, machine design, or shop subjects, or of new laboratory applications, apparatus, or appliances.

What have you new along some of these lines? Why not let your light shine in the Bulletin of our Society where others can read of your practice and possibly improve their teaching methods for the benefit of their M. E. students?

While the Committee will not promise publication of all the manuscripts received, it would like to receive one or two from each member who thinks he has something new which might be helpful to others.

Please think this over and let us hear from you this Spring.

Very truly,

W. T. Magruder, *Chairman*,
Walter W. Boyle
F. C. Wagner

ATTENDANCE IN ENGINEERING AND MINING SCHOOLS IN THE UNITED STATES.

BY WALTON C. JOHN,

U. S. Bureau of Education.

Courses.	Freshmen and Sophomores.	Juniors.	Seniors.	Total.	Specials.	Candidates for Advanced Degrees.
Civil Engineering	*11,204	2,433	2,018	12,167	492	313
Mechanical Engineering	* 6,027	2,637	2,481	13,682	160	95
Electrical Engineering	* 7,661	2,658	2,360	13,630	77	123
Chemical Engineering	2,427	1,082	1,097	4,606	23	111
Mining Engineering	752	438	536	1,726	85	49
Architectural Engineering	768	172	165	1,115	20	2
Textile Engineering	227	97	93	417	41	1
Industrial Engineering	225	165	69	459	1	1
Aeronautical Engineering	21	21	23	65	1	18
Sanitary Engineering	16	9	10	35	1	14
Geological Engineering	13	25	59	97	2	10
Ceramic Engineering	84	37	20	141	2	—
Agricultural Engineering	81	31	21	133	3	7
Engineering General and Unclassified	386	142	105	633	6	—
Miscellaneous	348	242	157	747	2	6
Chemistry	317	170	223	710	9	108
Physics	19	7	39	65	—	13
Architecture	469	149	154	772	32	6
Metallurgy	65	76	66	207	3	6
General Science	6	6	9	21	—	2
Six courses at Massachusetts Institute of Technology	291	140	224	655	37	35
Total in 1923	31,407	10,747	9,929	52,083	997	920
in 1922	32,178	11,446	8,520	52,144		

* The figures show the enrollment, based upon the undifferentiated courses of the freshman—sophomore years.

BOOK REVIEWS.

Engineering Economics. Second Edition. J. C. L. Fish. 311 pages, 6 x 9. McGraw-Hill Book Co.

A most extended revision of the first edition correcting the false impression that "engineering economics is not a choice of structure, but, rather a choice of investment." Contains: Analysis of the problem of investment; Practical Analysis of first cost; Business units; Irreducible data of the problem of investment; Business Statistics; Valuation; Engineering reports, etc. The material is well arranged and presented in such a manner as to form a desirable text book for teaching Engineering Economics in Engineering Schools.

H. E. D.

Electric Transients. C. E. Magnusson, A. Kalin, J. R. Tolmie. 190 pages, 6 x 9. McGraw-Hill Book Co.

A brief, elementary outline of the fundamental principles of electric transient phenomena and their application to quantitative problems. The material is well chosen and supplemented by many oscillograms of transients, easily reproduced in electrical engineering laboratories.

H. E. D.

OBITUARY.

Harry Harkness Stoek.

Born in Washington, D. C. January 16, 1866. Died March 1, 1923.

Received his early education in the public schools of that city, graduating from the Central High School in the first class to graduate from a high school in the national capitol in 1883.

In 1887 graduated from Lehigh University with the degree of Bachelor of Science in Mining and in 1888 received the degree of Engineer of Mines after a year of postgraduate study at Lehigh University in Mining and Metallurgy.

Since 1909 had been Professor of Mining Engineering and Head of the Department of Mining Engineering, University of Illinois.

Until the Illinois state government was reorganized so as to do away with the commission form of administration Professor Stoek served as Secretary of the Illinois Mine Rescue Commission and as a member of the Mining Investigation Commission.

Professor Stoek is a Past President of the Coal Mining Institute of America and also of the Illinois Mining Institute. Professor Stoek was a member of the American Institute of Mining and Metallurgical Engineers, International Railway Fuel Association, American Association for the Advancement of Science, Society for the Promotion of Engineering Education, American Mining Congress, Delta Phi, Sigma Xi, Tau Beta Pi and Delta Mu Epsilon.

Professor Stoek was also Consulting Engineer for the United States Bureau of Mines. During the summer of 1922 Professor Stoek prepared Technical Paper 326 "Fires in Bunker and Cargo Coal" for the U. S. Bureau of Mines, which is now in press.

During the Christmas holidays Professor Stoek went to Washington D. C. to aid in the preparation of the preliminary report on coal storage for the Fact Finding Coal Commission, of which he was a member. This preliminary report was published January 15, 1923.

Professor Stoek was given the honorary degree of Doctor of Science by the University of Pittsburgh in June 1920, and also by Lehigh University October 14, 1922.

Professor Stoek was appointed to serve on a committee of engineers to make a study of the storage of coal by the American Engineering Council February 28, 1923.